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## POLICY RESEARCH WORKING PAPER

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# Why Higher Fiscal Spending Persists When a Boom in Primary Commodities Ends

*Bruno Boccara*

After the initial boom in fiscal spending that accompanies a commodity boom, why do commodity-exporting countries tend to maintain higher spending levels despite a drop in commodity prices? Probably because of liquidity constraints and the costs of policy reversal.



## Summary findings

Boccara analyzes the fiscal policy of primary commodity exporters.

After the initial boom in fiscal spending that accompanies a commodity boom, he asks, why do commodity-exporting countries tend to maintain higher spending levels despite a drop in commodity prices? He identifies three factors that might explain the tendency: a pressure (from political constituents, for example) to keep spending, the difficulty of reversing policy (or disinvesting — the costs of firing people, for example), and the effects of limited indebtedness, or credit-rationing constraints.

Fiscal policy must be developed with these three factors in mind.

Using a fiscal policy optimizing model, Boccara examines evidence for the existence of these three factors. He uses the model's unconstrained and constrained Euler equations to estimate the Lagrange multipliers associated with the limited indebtedness constraint. The empirical work is done using data from Africa's franc zone countries.

The persistence of pressure to spend may not play an important role, says Boccara. More important in explaining the tendency to maintain spending levels after a commodity boom ends are liquidity constraints and the costs of policy reversal.

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# **Why Higher Fiscal Spending Persists When a Boom in Primary Commodities Ends**

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<sup>1</sup> Since the paper was written, the CFA Franc was devalued. This does not affect, in any way whatsoever, the methodology and the findings of this paper.

## 1 Introduction

Changes in commodity export prices have played an important role in explaining the economic performance of industrial and of developing countries. In the developing countries, commodity export prices are very important since more than 70 countries derive at least 50% of their export earnings from non-fuel primary commodities. In 1985, in Sub-Saharan Africa, primary commodities exports accounted for 94% of total merchandise exports.

For most countries, fluctuations in the international prices of the main commodity exports have important implications for government revenues since the government is likely to either own the production facilities (e.g, Nigeria for oil) or to have set up a price stabilization fund (e.g, Côte d'Ivoire for coffee). Furthermore, trade taxes are often an important source of revenues. Increased export revenues, following a commodity boom, usually result in a balance-of-payments surplus and an accumulation of international reserves.

Typically, following a commodity boom, primary commodities exporter LDC's have experienced a surge in government expenditures which continued in spite of the subsequent decline in the price of primary commodities. A survey of commodity booms for several

developing countries (Colombia<sup>1</sup>, Cameroon, Kenya, Nigeria and Jamaica) can be found in Cuddington (1989) who generalizes from countries' experience by concluding that

"there has been a tendency to overspend during and following commodity export booms, which has considerably reduced realizable welfare gains...The ratchet effect of increased government spending during booms, which proves difficult to reduce once the booms subside, is common." (pp. 154-55).

A similar pattern exists for the Franc Zone countries in Africa. For example, in 1975-77, Côte d'Ivoire experienced the coffee/cocoa boom (tripling of prices in 2 years) during which the government started an ambitious public investment program which continued in spite of the reversing trend in the coffee/cocoa prices. This led to the accumulation of foreign debt (73% of GDP in 1987 versus 35% of GDP in 1980). By 1980 the public sector deficit had reached 12% of GDP. In Niger, the government and its creditors did not react to the collapse of uranium prices in the early 1980's and fiscal policy remained expansionary until 1983. Although Senegal did not experience the same magnitude of fluctuations in its term of trade as the rest of the West African Monetary Union countries, it nevertheless continued its expansionary policy, maintaining private consumption and expanding public consumption, when the price of phosphate fell.

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<sup>1</sup>More detailed work for Colombia and the coffee boom is available in Cuddington (1986).

This brief review of the experience with commodity booms of some Sub-Saharan African countries suggests that in many cases countries may even find themselves worse off after the boom and that their responses have not been optimal<sup>2</sup> (in the sense of not using periodic surge in export commodity prices to restore external balance and promote economic growth).

The purpose of this paper is to analyze fiscal policy in primary commodities exporter developing countries. The paper characterizes the environment in which fiscal policy decisions are made by introducing three effects (pressure to spend, limited disinvestment or policy reversal and limited indebtedness) and suggests that these three effects may explain the lack of consumption smoothing by the fiscal authorities<sup>3</sup>. It uses an optimizing model of government spending to look for evidence, using data for the Franc Zone countries in Africa, of the existence of

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<sup>2</sup>There are naturally some exceptions to this. Botswana and Cameroon limited the increase in government spending during the commodity booms. The experience of Cameroon (with a comparison with that of Côte d'Ivoire and Senegal) is reviewed in Devarajan and De Melo (1987).

<sup>3</sup>To test the permanent income hypothesis for government expenditures, one can regress (see, Cuddington and Urzúa, 1987 for a similar approach) the logarithm of government expenditure (with separate regressions for consumption and investment expenditures) on a permanent and a cyclical component of the logarithm of government revenues (a decomposition of the logarithm of government revenues into a permanent and a cyclical component can, for example, be obtained by the Beveridge and Nelson (1981) method). However, the decomposition itself is meaningless unless a sufficiently large (and, if possible, not restricted to years covering a commodity boom and a commodity bust) number of observations is available. Furthermore, this testing approach is valid if government revenues can be assumed to be exogenous (i.e., no tax instrument available). This may be a reasonable approximation for lesser developed and highly primary commodities dependent African economies. It is also possible to test for an asymmetric fiscal response to commodities booms and busts by allowing for different coefficients whether the cyclical component is positive or negative.

these three effects and uses Euler equations for the unconstrained and the constrained version of the model to evaluate Lagrange multipliers for the constraint associated with the limited indebtedness effect.

## **2 Limitations to Fiscal Expenditure Adjustments and Government's Response**

A positive (negative) terms of trade shock resulting from an increase (decrease) in the international price of a country's main export commodity or from a resource discovery (e.g, exploitation of new oil reserves for Cameroon) implies an increase (decrease) in wealth. Optimally, the government, if it has rational expectations and behaves according to the permanent income theory, should use commodity booms and busts to smooth its consumption expenditures. In particular, as argued by Cuddington (1988), the optimal response for an economy would be to estimate the present value of the windfall gain (loss) and to limit the increase (decrease) in consumption expenditures to the perpetuity equivalent of this windfall. However, as illustrated earlier with the experience of African countries, commodity booms are in most cases accompanied by excessive increases in consumption expenditures and by ambitious investment programs<sup>4</sup>. This has a tendency to lock countries into

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<sup>4</sup>Investment in projects (preferably with low disinvestment costs if phasing out becomes necessary) with an internal rate of return (measured at appropriate shadow prices) that exceeds the country's opportunity cost of capital could be welfare enhancing. In practice, this is very unlikely to be the case (white elephants). Thus, although the permanent income theory defines optimal behavior

levels of spending which, in spite of their unsustainability (because of the resulting high level of foreign debt), are difficult to reverse.

Rejection of the permanent income hypothesis can naturally be explained if it can be argued that temporary booms were genuinely believed to be permanent or that governments operate with very short time horizons. The approach adopted by this paper is to characterize the environment in which a forward-looking infinitely lived government makes its fiscal decision and to look for evidence of the existence of operative constraints and/or costs faced by the government which may prevent it from behaving in a manner consistent with the permanent income theory. The characterization of the environment in which fiscal policy decisions must be made is described below.

#### *Pressure to spend effect*

If the public and/or the private sector face credit constraints which are relaxed during a boom, it is likely that there will be a surge in consumption expenditures at the onset of the boom. However, even in the absence of credit constraints, the same effect on spending can be attained if the government finds itself unable to restrict expenditures once it is known that

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as consumption smoothing (i.e., investing in projects is a form of savings), we ignore this and work with total government expenditures without distinguishing between consumption and investment expenditures.



additional government revenues are available<sup>5</sup>. In a country where there are a lot of unmet needs, special interest groups or government agencies may pressure the government into spending immediately a large amount of the increase in wealth if those groups or agencies feel uncertain whether they will be able to benefit from increased government spending if it is postponed.

Thus, the pressure to spend effect can be given a political economy cost interpretation. The constituents can exert pressure on the government (i.e. threat of political upheavals such as food riots or electoral defeat following the removal of subsidies on staple food or public transit) if it does not follow their desired fiscal policy.

The pressure to spend effect, expressed as a constraint on the budget's surplus, can, for example, be written as

$$Y_{t+s} - G_{t+s} \leq S^* \quad (S^* \geq 0) \quad (1)$$

We now examine a cost interpretation of the pressure to spend effect. There are two alternative views of how the pressure to spend arising from a commodity boom can manifest itself into a political crisis. One can either consider that the resulting crisis is an all or nothing event (with a fixed cost  $C_1$ , see

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<sup>5</sup>Cameroon, which avoided spending immediately its surplus from the coffee/cocoa (75-77) and oil boom, channeled the additional revenues (without divulging the amount) into accounts which did not figure in its government's budget.

Dornbusch, 1988) or that there can be different degrees (with increasing costs) in the seriousness of the crisis (e.g., a minor strike, a riot, a general strike or the overthrow of the government).

In the first case, an appropriate formulation for the expected cost is

$$E_t(C_1) = p_t(Y_t - G_t) C_1 \quad (2)$$

where  $p_t$ , the probability of a crisis occurring in period  $t$  is an increasing function of the budget's surplus  $Y_t - G_t$  for that period. We assume that  $Y_t$  and  $G_t$  are immediately known to the constituents (i.e., no lag on acquiring information)<sup>6</sup>.

In the second case, an expression for the expected cost is, for example,

$$E_t(C_1) = 1_{[Y_t - G_t > 0]} C_1(Y_t - G_t), \quad C_1' \geq 0 \quad (2')$$

This formulation which we consider intuitively more appealing for the type of political crisis that is being discussed is

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<sup>6</sup>The probability  $p_t$  could also be expressed as a function of  $Y_{t+1} - Y_t$  or of  $(Y_{t+1} - Y_t)/Y_t$ . However, the probability of the constituents acting on their threat of rioting should be related to their knowledge of the government's action and thus be a function of  $G_t$ . The constituents could also act on their threat with a lag, giving the government several periods to adjust its spending. This would only complicate the problem by adding lagged terms in the function  $p_t$ .

selected for the empirical application<sup>7</sup>.

Note that the expected cost  $E(C_1)$  associated with the pressure to spend effect has a functional form which is consistent with the functional form selected for the corresponding constraint in the sense that its expected value is zero whenever the constraint is assumed to be non binding (with  $S' = 0$ ) and that it is an increasing function of the quantity on which the constraint is imposed<sup>8</sup>. This suggests that the expected cost  $E(C_1)$  should be expressed as the product of an indicator function (indicating whether or not a crisis occurs) and of a measure of the seriousness of the crisis, for example, the square of the difference between the government's chosen and the constituents' desired policy.

#### *Limited disinvestment or policy reversal effect*

The marked increase in government expenditures which typically follows a commodity boom can, for example, translate into investment spending on projects or into an increase in the size (and/or the wage) of the public labor force. Once this spending pattern is in place, it may become difficult to reverse. The government finds itself trapped by recurrent expenditures which are inflexible or even irreversible. Furthermore, the longer the

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<sup>7</sup>It leads to a more tractable version of the model since the functional form for the cost (convex) does not have to be a probability.

<sup>8</sup>Thus,  $C_1$  is related to the strength of the pressure to spend effect and as such measures the extent to which the corresponding constraint is binding.

higher level of government spending has been sustained, the harder *a priori*, it will be to reverse. Thus, the government faces policy reversal costs (e.g., disinvestment costs for a project already started, labor firing costs) which *a priori* increase with the level of total expenditure (investment) and therefore increase with the time span of the commodity boom. However, this effect could theoretically become inexistant for an economy in which the commodity boom has lasted sufficiently long so that either it is at full capacity and firing costs are small (i.e., overemployment) and/or the marginal investment projects have a lower internal rate of return than the projects undertaken at the onset of the commodity boom. This is unlikely, excluding perhaps some oil exporters, to be the case for the majority of developing countries.

The limited disinvestment or policy reversal effect, expressed as a constraint on government spending, can, for example, be written as

$$G_{t+s} - G_{t+s-1} \geq \omega \quad (\omega \geq 0) \quad (3)$$

which corresponds to a policy reversal interpretation.<sup>9 10</sup>

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<sup>9</sup>Equation (3) means that there is pressure on the government whenever it decreases the level of real government spending ( $\omega = 0$ ).  $\omega > 0$  can be justified if policy reversal is defined in terms of real government spending per capita.

<sup>10</sup>A limited disinvestment interpretation can, for example, be written as

$$\frac{G_{t+s}}{K_{t+s-1}} \geq \rho$$

which is equivalent to imposing a lower bound on investment.

To formulate the limited disinvestment or policy reversal effect as a cost, that of contracting fiscal policy during a commodity bust, we once again assume that the political crisis (a function of the state of the economy and of the actions of the government) is of varying intensity and we ignore fixed cost formulations.

The nature of a crisis occurring (its likelihood and its magnitude) in period  $t$  should be a function of the capital stock  $K_{t-1}$  (i.e., the state of the economy at the beginning of the period) and of the government expenditures  $G_t$  (again we postulate that the government's action influences the way the constituents respond). As has been explained earlier, the likelihood and/or the magnitude of a crisis occurring at the onset of an adjustment program adopted by the government should be increasing in  $K_{t-1}$  (for example, cutting teacher's salaries is likely to be more disruptive if the number of teachers is high) and should be decreasing in  $G_t$ . Assuming away any lag in the constituents acquiring information about the economy and defining policy reversal by  $G_t - G_{t-1} < 0$ , the expected cost  $E(C_2)$  can, for example, be expressed as

$$E_t(C_2) = 1_{[G_t - G_{t-1} < 0]} C_2(G_t, K_{t-1}) \quad (4)$$

with

$$\frac{\partial C_2(G_t, K_{t-1})}{\partial G_t} \leq 0 \quad ; \quad \frac{\partial C_2(G_t, K_{t-1})}{\partial K_{t-1}} \geq 0 \quad (5)$$

A simpler functional form, adopted for the empirical application, which is consistent with the constraint formulation of the limited disinvestment or policy reversal effect (for  $\omega = 0$ ) is given by

$$E_1(C_2) = 1_{[G_t - G_{t-1} \leq 0]} C_2(G_{t-1} - G_t) ; C_2' \geq 0 \quad (4')$$

Note that *a priori*, considering changes in government expenditures of equal magnitude, the cost of a political crisis triggered by a transition from a high level of spending to a low level of spending (i.e., adjustment) should exceed that of a political crisis triggered by the lack of transition from a low level of spending to a high level of spending. In the former case, the government requires its constituents to readjust their consumption level to a lower level (to which they may no longer be used to if the commodity boom has lasted sufficiently long) while in the latter case, it only requires its constituents not to switch to a higher consumption level (to which they are not yet accustomed).

#### *Limited indebtedness effect*

The third and last effect which characterizes the environment in which the government must set its fiscal policy is a credit rationing constraint.

At the onset of a commodity bust, as long as foreign financing is available, the country is able to sustain its spending pattern, thus avoiding the political costs of reversing its fiscal policy. Naturally, foreign reserves are depleted and/or the level of foreign debt rises. Sooner or later, the country will face a borrowing constraint on the international capital market and adjustment, often at the request of the lending institutions (e.g., IMF), will have to take place. Poor investment projects, substantial government's budget deficit and large external indebtedness will then make adjustment a lot more costly than it would have been, had the government been able to manage better (in the sense of behaving more closely to what is predicted by the permanent income theory) its commodity boom.

The limited indebtedness effect, expressed as a constraint on wealth, is written as

$$A_{t+g} \geq -A^* \quad (6)$$

### 3 Fiscal Policy Optimizing Model

The purpose of this section is to formulate a fiscal policy optimizing model which incorporates the three effects introduced above with the pressure to spend and the limited disinvestment or policy reversal effects expressed as costs and the limited indebtedness effect expressed as a constraint.

Our model of government's behavior is an expenditure choice model based on intertemporal optimization in a dynamic stochastic environment. The government's income  $Y_t$  is a function of the international price  $P_t^*$  of the main export commodity. Since  $P_t^*$  is a general stochastic process,  $Y_t$  is also a general stochastic process. We assume that the government maximizes a time separable utility function with an instantaneous utility function of real government expenditures  $G_t$  for period  $t$  and of services received from the beginning of period  $t$  capital stock  $K_{t-1}$ . Assuming those services to be proportional to the capital stock, we have the following maximization problem:

$$\begin{aligned} \text{Max } E_t \sum_{s=0}^{\infty} (1+\theta)^{-s} [U(G_{t+s}, K_{t+s}) \\ G_{t+s} \quad \quad \quad -C_1(Y_{t+s} - G_{t+s}) - C_2(G_{t+s-1} - G_{t+s})] \end{aligned} \quad (7)$$

subject to the capital and wealth accumulation equations

$$K_{t+s} = \gamma G_{t+s} + (1-\delta) K_{t+s-1} \quad (8)$$

$$A_{t+s} = (1+r) A_{t+s-1} + Y_{t+s} - G_{t+s} \quad (9)$$

and to the constraint equation (6)

$$A_{t+s} \geq -A^* \quad (6)$$

where



$E_t$  is the expectation conditional on information available at time  $t$ ;

$U$  is the one period utility for consumption and services received from the capital stock;

$\theta$  is the constant rate of time preference;

$\gamma$  is the constant fraction of government expenditures allocated to investment;

$\delta$  is the constant rate of depreciation;

$r$  is the constant real rate of interest;

$Y_t$  is real government revenues; and

$A_t$  is the real end-of-period wealth.

The decision problem is sequential with the following timing. At the beginning of each period, the government learns  $Y_t$ . The government then reoptimizes by selecting  $G_t$  for the period. This, in turn, determines  $A_t$  and  $K_t$ . Thus, for this problem, the control variable is government spending  $G_t$  and the state variables are the capital stock  $K_t$  and the wealth  $A_t$ .  $A_t$  should be thought of as liquid wealth.  $K_t$  is not considered to be a part of wealth because the capital is assumed to have no resale value (once spent, investment is sunk).

Even without constraints, analytical solutions to the optimization problem when income is stochastic cannot in general be derived, except in some simplifying cases. (See, for example, Blanchard and Fischer, Chapter 6, 1989.) Nevertheless, we can write first-order conditions which are necessary for maximization

of the welfare function. The first-order conditions are derived from an application of the Kuhn-Tucker conditions to the Bellman equation.

The value function  $W_t$  satisfies the following recursive equation (Bellman equation)

$$\begin{aligned}
 W_t(A_t, K_t) = \underset{G_t}{\text{Max}} \big[ & U(G_t, K_t) + (1+\theta)^{-1} E_t(W_{t+1}(A_{t+1}, K_{t+1})) \\
 & - C_1(Y_t - G_t) - C_2(G_{t-1} - G_t) \\
 & + \lambda_t(A_t - A^*) \big]
 \end{aligned}
 \tag{10}$$

where  $\lambda_t$  is the Lagrange multiplier (known at time  $t$ ) associated with the borrowing constraint at time  $t$ . The Lagrange multiplier at time  $t$  is equal to the increase in the objective function (from time  $t$  on) if the corresponding (current) constraint is relaxed by one unit. If the constraint is binding,  $\lambda_t$  should be positive since overall utility would increase if the government were able to borrow an extra dollar. It cannot be negative since, given the absence of an upper bound on wealth, the limited indebtedness constraint does not prevent the government from saving more.

To derive the Euler equation, we derive the first-order condition associated with the equation above, eliminate the value function by using the envelope theorem, push one period forward and apply rational expectations. Assuming, for ease of computation, that the real rate of interest is equal to the rate of time

preference ( $r = \theta$ ), that there is no depreciation ( $\delta = 0$ ) and that all government spending is allocated to some form of capital ( $\gamma = 1$ ), we obtain the following equation:

$$\begin{aligned}
& (1+r) [U'_{K_t}(G_t, K_t) - U'_{K_{t-1}}(G_{t-1}, K_{t-1})] \\
& + U'_{G_t}(G_t, K_t) - U'_{G_{t+1}}(G_{t+1}, K_{t+1}) \\
& + (1+r) [U'_{G_t}(G_t, K_t) - U'_{G_{t-1}}(G_{t-1}, K_{t-1})] \\
& + C'_1(Y_t - G_t) - C'_1(Y_{t+1} - G_{t+1}) \\
& + (1+r) (C'_1(Y_t - G_t) - C'_1(Y_{t-1} - G_{t-1})) \quad (11) \\
& + (1+r) (-C'_2(G_{t-2} - G_{t-1}) + C'_2(G_{t-1} - G_t)) \\
& - C'_2(G_t - G_{t+1}) + C'_2(G_{t-1} - G_t) \\
& = \\
& \lambda_{t+1} - \lambda_t - r\lambda_t \\
& + u_t + u_{t+1}
\end{aligned}$$

where  $u_t$  and  $u_{t+1}$  are error terms with zero means and respectively uncorrelated with any information available at time  $t-1$  and at time  $t$ . All derivations are shown in Appendix 1.

#### 4 Description of the Test

Zeldes (1989) shows that empirical rejections of the permanent income theory can be explained by the presence of liquidity constraints. He derives the Euler equations for a consumption optimizing model with and without borrowing constraints and tests

whether borrowing constraints are binding by testing whether the unconstrained Euler equations are violated. This approach follows Hall(1978). The advantage of testing Euler equations is that it is not necessary to specify the stochastic process for the exogenous variable (in our case government revenues) and that it is not necessary to obtain a closed form solution for consumption (i.e. fiscal policy). (See, for example, Mankiw (1985).)

A currently binding constraint leads to the violation of the unconstrained Euler equation. We do not have a closed form expression for the Lagrange multiplier. It should be a function of the state variables at  $t$  and of expected values of these variables from time  $t+1$  on<sup>11</sup>. Therefore, since the Lagrange multiplier appears in the error term, estimation of equation (11) with a data set that includes constrained observations (i.e., observations for which at least one of the constraint is binding) will lead to inconsistent parameter estimates.

As a consequence, it is necessary to split the sample of observations into two groups: one for which the borrowing constraint is *a priori* not binding and the other one for which the

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<sup>11</sup>Since  $K_{t+1}$  can be expressed as a function of  $K_t$ ,  $A_t$ ,  $A_{t+1}$  and  $Y_{t+1}$ , ( $K_{t+1} = \gamma((1+r)A_t + Y_{t+1} - A_{t+1}) + (1-\delta)K_t$ ) the Lagrange multipliers are functions of  $A_t$ ,  $K_t$  and of future values of  $A_t$  and of  $Y_t$ .

constraint is a priori binding<sup>12</sup>. Estimation of the Euler equation for the data set restricted to unconstrained observations will yield consistent parameter estimates.

The test of liquidity constraint is based on an estimator of the error term of the constrained Euler equation. This estimator is obtained by getting a numerical estimate of the residual in equation (11) using the consistent parameters obtained by the estimation of that same equation for the unconstrained observations.

These numerical estimates of the residuals are the sum of the expression involving the Lagrange multipliers in the right hand side of equation (11), the true residual and an error term. If the sample is large enough, the sample means of the true residual and of the error term will converge to zero and, by averaging the numerical estimates of the residuals, we will obtain an estimate of the average of the expression involving the Lagrange multipliers in the right hand side of equation (11) for the group of constrained observations.

Taking the average over T observations of the residual of

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<sup>12</sup>Note that even if unconstrained observations are included in the group of constrained observations (and therefore, excluded), the parameter estimates will still be consistent but that if one or more constrained observations are included in the group of unconstrained observations, the parameter estimates will be inconsistent.

equation (11), we obtain<sup>13</sup>

$$\frac{1}{T} [ \lambda_{T+1} - \lambda_1 - r \sum_{s=1}^{s=T} \lambda_s ] \quad (12)$$

## 5 Estimation Results

The model is tested for Franc Zone countries in Africa. The Franc Zone (or CFA Zone) in Africa is the largest and most enduring currency block. Thirteen countries are engaged in a monetary union which involves pooling of foreign reserves, a common currency whose convertibility is guaranteed by France, and a fixed exchange rate with the French Franc. (For a description of the functioning of the Franc Zone, see, for example, Bhathia, 1985 and Guillaumont and Guillaumont, 1988.) The rules of the Franc Zone make it an ideal case with which to study fiscal policy in primary commodities exporter developing countries. By abdicating the right to devalue and by adopting rigid monetary rules, the member countries (which can nevertheless borrow abroad) only have one degree of freedom left, that of setting fiscal policy, in defining their adjustment and growth strategy.

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<sup>13</sup>Note that there are realizations of  $Y_t$  such that the model with the three effects expressed as constraints does not have a solution. (The three constraints may be simultaneously binding and inconsistent with each others.) However, as long as borrowing constraints are absent (although borrowing costs may become very high), it is possible to formulate the model with the pressure to spend and the limited disinvestment or policy reversal effects expressed as constraints. In that case, it can be shown that the Lagrange multipliers associated with these two constraints always appear as a difference in the residual (i.e., multiplier at time  $t$  - multiplier at time  $t-1$ ) and therefore, that it is impossible to obtain an estimate of the average of these multipliers.

Government statistics for African countries are very poor and data on government revenues and expenditures are especially scarce. Relying on the International Financial Statistics (IMF), the African Economic and Financial Data (World Bank) and World Bank country reports, government expenditure and revenue<sup>14</sup> data were retrieved for the following countries and for the following years: Burkina Faso (1973-87); Cameroon (1975-87); Côte d'Ivoire (1969-87); Gabon (1973-76 and 1979-87); Senegal (1977-1987); and, Togo (1977-87). Variables for which we had several data source were systematically checked for consistency. Given the lags in the Euler equation ( $t-2, t-1$  and  $t+1$ ), an observation qualifies for inclusion in the data set if data for the preceding two years and for the following year is also available. The final data set available to test the model includes 61 observations. Finally, the capital K variable had to be constructed. Since no data on capital stocks were available, a time series for K was constructed (using available investment data) starting in 1960<sup>15</sup> using an initial capital output ratio of 5 and a depreciation rate of 5 percent. Taylor (1979) suggests as a rule of thumb a depreciation rate of 4% and a capital output ratio of 3. Since he is referring to developing countries as a whole, slightly higher figures are

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<sup>14</sup>In some cases, data on government revenue was unavailable. However, a figure could be constructed using data on government's expenditures and primary deficit.

<sup>15</sup>K is built recursively as  $K_t = K_{t-1} (1-\delta) + I_t$  with  $K_0 = 5 Y_0$ . Although all series, except Côte d'Ivoire which starts in 1969, start in 1973 or after, the capital serie was initialized in 1960 in order to reduce sensitivity to the choice of the initial capital output ratio.

selected for African countries.

The criteria used for splitting the data is as follows:

1) the limited indebtedness constraint is assumed to be binding whenever real net foreign assets of the monetary sector<sup>16</sup> are negative or low<sup>17</sup>.

Real net foreign assets of the monetary sector is not what the wealth variable  $A$  is supposed to measure. However, it is *a priori* the case that the government faces a liquidity constraint whenever real net foreign assets are low. In particular, the absence of a market for government bonds in the Franc Zone prevents open market operations. Therefore, all government borrowing is essentially foreign, either directly through the central bank or indirectly through public enterprises which in turn borrow abroad. Thus, the real net foreign asset variable is an indicator of the latent wealth variable  $A$ .

Note that when a constraint is binding at time  $t$ , more than one observation must be eliminated since the corresponding Lagrange

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<sup>16</sup>*Avoirs Exterieurs (Net)*

<sup>17</sup>The notion of "low" is itself *ad hoc*. However, for each country, time series observations for the wealth variable were such that the difference between the largest value for which the observation was rejected (i.e., constraint assumed to be binding) and the smallest value for which the observation was not rejected was substantial (i.e., well in excess of the magnitude of the largest of the "low" values). Furthermore, excluding observations with a negative wealth or with a negative or "low" wealth did not produce very different results. Therefore, since the larger number of observations in the first case implies more degrees of freedom, the criteria adopted for splitting the data is that of excluding observations with a negative wealth variable.



multiplier also appears in the error term at time  $t-1$  and at time  $t+1$ .

Using the criteria above, 31 observations had to be eliminated on the basis of wealth alone and the unconstrained Euler equation data set which can *a priori* be used for estimation has 31 observations.

The model is specified as follows.

Both utilities are assumed to be quadratic with

$$U(G_t, K_t) = A - \frac{\alpha}{2} (G_t - \bar{G})^2 - \frac{\beta}{2} (K_t - \bar{K})^2 \quad (15)$$

where  $G$  and  $K$  are country specific<sup>18</sup>.

Alternatively, we could assume the instantaneous utilities to be of the constant elasticity of substitution form. However, meaningful convergence results were difficult to obtain with this specification.

The costs are also assumed to be quadratic with

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<sup>18</sup>Note that  $G$  and  $K$  require time subscripts if it is deviations from the respective permanent components which are penalized. However, a meaningful value of  $G$  (and of  $K$  constructed, for example, by using a permanent decomposition of public investment) can only be obtained if we have enough observations. For simplicity, we ignore that differences in the permanent components from one period to the next appear in the first-order condition.

$$C_1(Y_t - G_t) = 1_{[Y_t - G_t \geq 0]} \frac{\lambda}{2} (Y_t - G_t)^2 \quad (16)$$

$$1_{[Y_t - G_t \geq 0]} = 1 \text{ if } Y_t - G_t \geq 0 ; 0 \text{ otherwise}$$

$$C_2(G_t, G_{t-1}) = 1_{[G_t - G_{t-1} \leq 0]} \frac{\mu}{2} (G_{t-1} - G_t)^2 \quad (17)$$

$$1_{[G_t - G_{t-1} \leq 0]} = 1 \text{ if } G_t - G_{t-1} \leq 0 ; 0 \text{ otherwise}$$

where the indicator functions are constructed as dummies using data for each country on  $Y_t$ ,  $G_{t-1}$  and  $G_t$ . (An exponential formulation for the costs (i.e.  $\lambda \exp(Y_t - G_t)$ ;  $\mu \exp(G_{t-1} - G_t)$ , does not require the use of indicators (dummies) and is such that the costs are non zero for all observations.)

Under these assumptions, the unconstrained Euler equation becomes (for each country,  $K$  and  $G$  cancel out):

$$\begin{aligned} & \beta(1+r)(K_t - K_{t-1}) + \alpha(G_t - G_{t+1}) + \alpha(1+r)(G_t - G_{t-1}) \\ & + \lambda 1_{[Y_{t+1} - G_{t+1} \geq 0]} (Y_{t+1} - G_{t+1}) \\ & - \lambda 1_{[Y_t - G_t \geq 0]} (1+r)(Y_t - G_t) \\ & + \lambda 1_{[Y_{t-1} - G_{t-1} \geq 0]} (1+r)(Y_{t-1} - G_{t-1}) \\ & + \mu 1_{[G_{t+1} - G_t \leq 0]} (G_t - G_{t+1}) \\ & - \mu 1_{[G_t - G_{t-1} \leq 0]} (1+r)(G_{t-1} - G_t) \\ & + \mu 1_{[G_{t-1} - G_{t-2} \leq 0]} (1+r)(G_{t-2} - G_{t-1}) \\ & = 0 \end{aligned} \quad (18)$$

Note that since a utility function is defined up to an affine transformation, neither  $A$  (which does not appear in the equation) nor  $\alpha$  (or  $\beta$ ) are identified. Therefore, setting  $\alpha$  equal to 1, there are three parameters to be estimated<sup>19</sup>:

$\beta$  a utility parameter;

$\lambda$  a cost parameter for the pressure to spend effect; and

$\mu$  a cost parameter for the limited disinvestment effect<sup>20</sup>.

The stochastic Euler equation that must be satisfied in equilibrium implies orthogonality conditions that depend in a non linear way on the variables and on the unknown parameters. Estimation of the model is done by Non Linear Least Squares. However, given the presence of  $u_t$  in the error term, consistency of the parameter estimates require the use of a generalized instrumental variables method.<sup>21</sup> The estimation technique used

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<sup>19</sup>The estimation results are not very sensitive to the choice of the discount rate. The discount rate (equal to the rate of time preference) selected is 10 percent.

<sup>20</sup>Note that the three parameters above are actually all measured relative to  $\alpha$  (i.e.,  $\beta/\alpha$ ,  $\lambda/\alpha$  and  $\mu/\alpha$ ) and are also (since the first-order condition is homogeneous of degree one) independent of the unit in which all variables are expressed. The parameters can be given the following interpretation. Let  $C_0$  designate the disutility of government spending deviating from  $G$  by an amount  $Q$ . Then, the disutility associated with the pressure to spend effect for a surplus in the amount of  $Q$  is  $\lambda C_0$  while the disutility associated with the limited disinvestment or policy reversal effect for a reversal of policy in the amount of  $Q$  is  $\mu C_0$ . A more interesting quantity is the ratio  $\mu/\lambda$  which measures the relative importance of the costs and which a priori, as has been argued earlier, should be greater than one. An alternative formulation is to write all the quantities in terms of percentage of GDP. However, the results obtained were not satisfactory (insignificant parameters). In any case, we are more interested in testing whether the parameters are of the expected sign and different from zero rather than measuring their magnitude.

<sup>21</sup>The Euler equation is of the form  $E_t(f(x_{1..t}, \beta)) = 0$  where  $f(x_{1..t}, \beta)$  is a vector of residuals. The use of instruments  $z_t$  means that we are minimizing a quadratic form of residuals which have been projected ( $f(x_{1..t}, \beta) \otimes z_t$ ) into the

follows Hansen (1982) and Hansen and Singleton (1982).

As argued in Hansen (1982), the method of moments estimator used is consistent even when the disturbances are serially correlated and the instruments are not exogenous. However, the asymptotic covariance matrix of the estimates depends on the choice of the symmetric positive definite matrix used to construct the "distance" which is minimized. Newey and West (1987) show that if the highest order  $m$  of zero non correlation in the error term is non zero, the asymptotic covariance matrix used by Hansen and Singleton (1982) may be inadequate. This interferes with asymptotic confidence interval formation and hypothesis testing<sup>22</sup>.

As indicated earlier, the parameter estimates are not very

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vector space generated by the instruments  $z_i$ .

<sup>22</sup>Given the way observations from different time periods and from different countries are combined, the covariance structure is complicated. Since the model is estimated after a set of a priori constrained observations has been selectively deleted, the estimation data set is such that for each country the observations are not necessarily consecutive observations. This makes it very difficult to assume a common correlation structure (across time). AR(1) processes were fitted for the residuals (by countries) obtained for each model and did not indicate (except for three observations for Côte d'Ivoire) strong first-order correlations ( $\rho$  of the magnitude of 0.3 and insignificant). Furthermore, since the countries of the sample depend on different products for their exports and since the prices of these commodities are not very closely correlated (see, Honohan, 1990b), we can assume the commodities price shocks to be uncorrelated across countries. Since the countries in the sample are all in the Franc Zone, their monetary shocks are correlated and they share exactly (assuming away differences in the pattern of trade with countries other than France) the same exchange rate shocks. However, the majority of deleted observations corresponded to time periods of greater exchange rate volatility (i.e., greater variance) and the estimation data set is such that the most important component of the shocks should be the commodities price shocks.

Thus, we assume  $m=0$  and the estimation procedure adopted is the generalized instrumental variables method of Hansen and Singleton (1982) which is consistent and robust to both heteroscedasticity and serial correlation. (For  $m=0$ , Newey and West' and Hansen and Singleton' asymptotic covariance matrices coincide.)

sensitive to the value selected for  $r$  (a grid search with  $r$  varying in increment of 5 percent from 5 percent to 35 percent was conducted). Note that even with  $r$  fixed, the Euler equation remains non linear since the costs themselves are non linear. For example, with  $G_{t+1}$  as the dependent variable, the coefficient of  $G_t$  is (the indicator functions being constructed as dummies)

$$\frac{(2+r) [1 + \lambda 1_{[r_t - G_t \geq 0]} + \mu 1_{[G_t - G_{t-1} \leq 0]}] + \mu 1_{[G_{t+1} - G_t \leq 0]}}{1 - \lambda 1_{[r_{t+1} - G_{t+1} \geq 0]} - \mu 1_{[G_{t+1} - G_t \leq 0]}}$$

For  $r = 0.10$ , the parameter estimates (t-statistics in parentheses) are as follows

$\beta$	0.086	(1.68)
$\lambda$	-0.50	(0.52)
$\mu$	1.70	(1.80)

Given the functional form of the cost functions, it is very difficult to obtain significant estimates for the cost parameters since a large share of the observations for which the cost dummies are zeros have a zero cost<sup>23</sup>.

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<sup>23</sup>Prior to selectively deleting a priori constrained observations, the cost  $C_1$  is non zero for only 20 (out of 54 and not 61 due to the use of instruments) observations (out of which 11 remain in the estimation data set) and the cost  $C_2$  is non zero for only 25 observations (out of which 13 remain in the estimation data set). This is the rationale for the exponential functional form of the costs given above. Unfortunately, convergence was difficult to obtain with the exponential formulation.

Since the coefficient for the cost  $C_1$  is a priori expected to be significant, it may be that something else other than the budget surplus, and in particular a price signal (e.g., difference in the price of the main export commodity from one period to the next), determines the pressure to spend effect<sup>24</sup>. However, assuming that the cost is exclusively a function of a difference in price is not satisfactory since presumably the government's fiscal policy does affect whether or not and to what extent the pressure to spend effect manifests itself. This suggests to keep the same functional form for the cost  $C_1$  but to express the coefficient  $\lambda$  as a function of the magnitude of the change in the export unit value

$$\lambda (1 + 1_{[P_t^C - P_{t-1}^C \geq 0]} * (P_t^C - P_{t-1}^C))$$

which gives the following results:

$\beta$	0.083	(1.50)
$\lambda$	0.88	(1.05)
$\mu$	1.98	(2.21)

$\lambda$  is now positive and (although still insignificant) more significant than before.

Finally, since the estimation results seem to indicate that the cost  $C_1$  associated with the pressure to spend effect may not play a very significant role, the model is reestimated assuming that the parameter  $\lambda$  is zero which gives the following results:

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<sup>24</sup>Note that since we are working with Euler equations, we cannot test for the presence of a cost  $C_1$  which is exclusively a function of exogenous variables.

$\beta$	0.10	(2.48)
$\mu$	1.28	(2.75)

The parameter estimates above are of the expected sign and are significant. Given the nature of the data (poor quality and scarcity of observations) and the econometric techniques involved in estimating the model, the results above are reasonable and consistent with the predictions of the model. In particular, the results support the hypothesis of a limited disinvestment effect since the estimated Euler equation is consistent with that of the optimizing model presented in the paper for which the limited disinvestment effect is expressed as a cost of policy reversal.

The same model estimated on the entire set of observations yields the following parameter estimates:

$\beta$	0.023	(0.74)
$\mu$	0.46	(1.12)

The poor significance level and the substantial changes in the magnitude of the coefficients suggest the parameters are inconsistent due to misspecification<sup>25</sup> (i.e., the unconstrained Euler equation is not valid for the entire data set since the Lagrange multipliers for the constrained observations are non

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<sup>25</sup>This is an informal specification test. The hypothesis  $H_0$  that our model is well specified for the restricted data set cannot be tested by itself. However, assuming  $H_0$  to be true, we can reject the hypothesis  $H_1$  that the same model specification is valid for the entire data set. The results above clearly indicate that  $H_1$  should be rejected.

zero). We now turn to computing an estimate of the average of the Lagrange multipliers associated with the limited indebtedness constraint.

For Côte d'Ivoire, observations up to 1975 have a positive wealth variable and are included in the data set. From 1976 until 1986 (except for 1978), the wealth variable is negative. Averaging the residuals from 1975 ( $\lambda_1 = 0$ ) to 1985 ( $\lambda_{1986} = \lambda_{12} \neq 0$ ), we obtain (in billions of 1985 CFA Francs) -0.027 which in turn is an estimate of

$$\frac{1}{11} [\lambda_{12} - 0.1 \sum_{s=2}^{s=11} \lambda_s]$$

Therefore, solving the equation above, we obtain the following positive (a priori  $\lambda_{12}$  is positive) estimate of the average of the Lagrange multipliers from 1976 to 1985

$$\sum_{s=2}^{s=11} \lambda_s = 10\lambda_{12} + 2.99$$

The above results naturally need to be interpreted cautiously since we are far from dealing with a large sample. However, the expected positive value of the average of the indebtedness constraint Lagrange multipliers for observations which are believed to be a priori constrained and the fact that estimation of the same model on the full data set leads to very different parameter estimates are evidence that the unconstrained Euler equation is



misspecified for the observations which were selectively deleted on the basis of the wealth variable and that the source of the misspecification is the presence of liquidity constraints<sup>26</sup>.

## 6 Conclusions

The purpose of this paper is to analyze fiscal policy behavior in primary commodities exporters. The paper suggests that the typical surge in fiscal expenditures which accompanies a commodity boom and the tendency to maintain that level of expenditures in spite of a subsequent decline in export commodity prices may be explained by the existence of a pressure to spend, a limited disinvestment and a limited indebtedness effects. These three effects characterize the environment in which fiscal policy must be set.

The empirical work is done with data from the Franc Zone countries in Africa. The paper uses a fiscal policy optimizing

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<sup>26</sup>A similar computation for Senegal, for which all the observations are *a priori* constrained, gives for the years 1980 to 1985 (with  $\lambda_{1980} = \lambda_1 \neq 0$  and  $\lambda_{1985} = \lambda_7 \neq 0$ )

$$\sum_{s=1}^{s=6} \lambda_s = 10(\lambda_7 - \lambda_1) - 1.25$$

which is inconclusive. For Burkina Faso, for which the 1977 and the 1984 observations are *a priori* unconstrained and all the observations in between *a priori* constrained, we obtain (with  $\lambda_{1977} = \lambda_1 = 0$  and  $\lambda_{1984} = \lambda_8 = 0$ )

$$\sum_{s=2}^{s=7} \lambda_s = 0.299$$

which is again consistent with the existence of liquidity constraints since the estimate of the average of the Lagrange multipliers over the 7 years period is unambiguously positive.

model to look for evidence of the existence of the three effects above and uses the unconstrained and constrained Euler equations of the model to estimate the Lagrange multipliers associated with the limited indebtedness constraint.

The estimation results suggest that the pressure to spend effect may not play an important role but that policy reversal costs and liquidity constraints are likely to play a role in explaining the behavior of fiscal policy in the Franc Zone countries in Africa.

Additional work applying the same techniques on a richer data set for the Franc Zone countries or on data for other primary commodities exporter countries is suggested.

Additional research along the lines of the political economy models explaining timing of stabilization (see, for example, Drazen and Helpman 1988, Alesina and Drazen 1989, Drazen 1990) is also suggested to understand why these effects exist and what are the forces behind them.

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## Appendix 1

### Derivation of the First-order Condition

The model is repeated here for convenience.

$$\begin{aligned} \text{Max}_{G_{t+s}} E_t \sum_{s=0}^{\infty} (1+\theta)^{-s} [ & U(G_{t+s}, K_{t+s}) \\ & - C_1(Y_{t+s} - G_{t+s}) - C_2(G_{t+s-1} - G_{t+s}) ] \end{aligned}$$

subject to

$$K_{t+s} = \gamma G_{t+s} + (1-\delta) K_{t+s-1}$$

$$A_{t+s} = (1+r) A_{t+s-1} + Y_{t+s} - G_{t+s}$$

and to

$$A_{t+s} \geq -A^*$$

The value function  $W_t$  satisfies the following recursive equation (Bellman equation)

$$\begin{aligned} W_t(A_t, K_t) = \text{Max}_{G_t} [ & U(G_t, K_t) + (1+\theta)^{-1} E_t(W_{t+1}(A_{t+1}, K_{t+1})) \\ & - C_1(Y_t - G_t) - C_2(G_{t-1} - G_t) \\ & + \lambda_t(A_t + A^*) ] \end{aligned}$$

The first-order condition is

$$\begin{aligned}
U'_{G_t}(G_t, K_t) + \gamma U'_{K_t}(G_t, K_t) - \left( \frac{1+r}{1+\theta} \right) E_t \left( \frac{\partial W_{t+1}(A_{t+1}, K_{t+1})}{\partial A_{t+1}} \right) \\
+ \left( \frac{\gamma(1-\delta)}{1+\theta} \right) E_t \left( \frac{\partial W_{t+1}(A_{t+1}, K_{t+1})}{\partial K_{t+1}} \right) \\
+ C'_1(Y_t - G_t) + C'_2(G_{t-1} - G_t) = 0
\end{aligned}$$

To eliminate the value function from the first-order condition above, we use the envelope theorem from which we obtain

$$\frac{\partial W_t(A_t, K_t)}{\partial A_t} = \lambda_t + \frac{1+r}{1+\theta} E_t \frac{\partial W_{t+1}(A_{t+1}, K_{t+1})}{\partial A_{t+1}}$$

$$\frac{\partial W_t(A_t, K_t)}{\partial K_t} = U'_{K_t}(G_t, K_t) + \frac{1-\delta}{1+\theta} E_t \frac{\partial W_{t+1}(A_{t+1}, K_{t+1})}{\partial K_{t+1}}$$

Assuming that  $r$  is equal to  $\theta$ , that  $\delta$  is equal to zero and that  $\gamma$  is equal to 1, we can rewrite the first-order condition as

$$\begin{aligned}
U'_{G_t}(G_t, K_t) - \left( \frac{\partial W_t(A_t, K_t)}{\partial A_t} \right) + \lambda_t \\
+ \frac{\partial W_t(A_t, K_t)}{\partial K_t} \\
+ C'_1(Y_t - G_t) + C'_2(G_{t-1} - G_t) = 0
\end{aligned}$$

The first-order condition at  $t-1$  is

$$\begin{aligned}
U'_{G_{t-1}}(G_{t-1}, K_{t-1}) + U'_{K_{t-1}}(G_{t-1}, K_{t-1}) - E_{t-1} \left( \frac{\partial W_t(A_t, K_t)}{\partial A_t} \right) \\
+ \left( \frac{1}{1+r} \right) E_{t-1} \left( \frac{\partial W_t(A_t, K_t)}{\partial K_t} \right) \\
+ C'_1(Y_{t-1} - G_{t-1}) + C'_2(G_{t-2} - G_{t-1}) = 0
\end{aligned}$$

We now impose rational expectations and we have:

$$\frac{\partial W_t(A_t, K_t)}{\partial A_t} = E_{t-1} \frac{\partial W_t(A_t, K_t)}{\partial A_t} + \epsilon_{1,t}$$

$$\frac{\partial W_t(A_t, K_t)}{\partial K_t} = E_{t-1} \frac{\partial W_t(A_t, K_t)}{\partial K_t} + \epsilon_{2,t}$$

where  $\epsilon_{1,t}$  and  $\epsilon_{2,t}$  are error terms with zero means and uncorrelated with any information available at time  $t-1$ .

Taking the difference between the first-order condition at  $t$  and the first order condition at  $t-1$  and using the assumption above, we obtain:

$$\begin{aligned}
U'_{G_t}(G_t, K_t) - U'_{G_{t-1}}(G_{t-1}, K_{t-1}) - U'_{K_{t-1}}(G_{t-1}, K_{t-1}) + \frac{r}{1+r} \frac{\partial W_t(A_t, K_t)}{\partial K_t} \\
+ \lambda_t + C'_1(Y_t - G_t) - C'_1(Y_{t-1} - G_{t-1}) \\
+ C'_2(G_{t-1} - G_t) - C'_2(G_{t-2} - G_{t-1}) \\
= \epsilon_{1,t} - \frac{1}{1+r} \epsilon_{2,t}
\end{aligned}$$

This gives:

$$\begin{aligned}
\frac{\partial W_t(A_t, K_t)}{\partial K_t} &= \left(\frac{1+r}{r}\right) [U'_{G_{t-1}}(G_{t-1}, K_{t-1}) - U'_{G_t}(G_t, K_t) + U'_{K_{t-1}}(G_{t-1}, K_{t-1}) \\
&\quad - \lambda_t + C'_1(Y_{t-1} - G_{t-1}) - C'_1(Y_t - G_t) \\
&\quad - C'_2(G_{t-1} - G_t) + C'_2(G_{t-2} - G_{t-1})] \\
&\quad + \frac{1+r}{r} \epsilon_{1,t} - \frac{1}{r} \epsilon_{2,t}
\end{aligned}$$

This enables us to obtain an expression for the partial derivative of the value function with respect to wealth

$$\begin{aligned}
\frac{\partial W_t(A_t, K_t)}{\partial A_t} &= U'_{G_{t-1}}(G_{t-1}, K_{t-1}) + U'_{K_{t-1}}(G_{t-1}, K_{t-1}) \\
&\quad + \left(\frac{1}{r}\right) [U'_{G_{t-1}}(G_{t-1}, K_{t-1}) - U'_{G_t}(G_t, K_t) + U'_{K_{t-1}}(G_{t-1}, K_{t-1}) \\
&\quad - \lambda_t + (1+r) C'_1(Y_{t-1} - G_{t-1}) - C'_1(Y_t - G_t) \\
&\quad - C'_2(G_{t-1} - G_t) + (1+r) C'_2(G_{t-2} - G_{t-1})] \\
&\quad + \frac{1+r}{r} \epsilon_{1,t} - \frac{1}{r} \epsilon_{2,t}
\end{aligned}$$

Using the envelope theorem, we finally derive the first-order condition as:



$$\begin{aligned}
& (1+r) [U'_{K_t}(G_t, K_t) - U'_{K_{t-1}}(G_{t-1}, K_{t-1})] \\
& + U'_{G_t}(G_t, K_t) - U'_{G_{t+1}}(G_{t+1}, K_{t+1}) \\
& + (1+r) [U'_{G_t}(G_t, K_t) - U'_{G_{t-1}}(G_{t-1}, K_{t-1})] \\
& + C'_1(Y_t - G_t) - C'_1(Y_{t+1} - G_{t+1}) \\
& + (1+r) (C'_1(Y_t - G_t) - C'_1(Y_{t-1} - G_{t-1})) \\
& + (1+r) (-C'_2(G_{t-2} - G_{t-1}) + C'_2(G_{t-1} - G_t)) \\
& - C'_2(G_t - G_{t+1}) + C'_2(G_{t-1} - G_t) \\
& = \\
& \lambda_{t+1} - \lambda_t - r\lambda_t \\
& + u_t + u_{t+1}
\end{aligned}$$

with

$$u_t = (1+r)\epsilon_{1,t} - \epsilon_{2,t}$$

and

$$u_{t+1} = -\epsilon_{1,t+1} + \epsilon_{2,t+1}$$

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